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Ink and Paper Saving For Sustainable Printing

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The aim of my research is to look for means to reduce the ink and paper consumption in printing. Previously, all text documents or in this case specifically 'final year thesis papers' were printed without the awareness of the number of papers used and ink consumed. This thesis leans towards green technology based systems of printing which can be termed as 'sustainable printing' that can benefit the environment and the cost of production for that case.

In the 21th century, global warming and climate changes have been the biggest issues addressed. The emission of a greenhouse gas during the production process of printing pollutes our environment. Printing is the 3rd largest industry while pulp and paper is the 3rd largest industrial polluter of our environment. This study case explores the impact of printing on the environment and looks for means to reduce it. Ink and paper savings not only save us money but also our environment and native natural resources. Different online tools such as InkSaver 2.0, ecoPrint2 Pro Ink and Paper Saver, and Ecofont have been analyzed.

This research is based on the current thesis guidelines of media engineering students at Helsinki Metropolia University of Applied Sciences. I have attempted to modify the thesis guidelines for saving ink and paper by applying techniques such as choosing the right ink-economical typeface, a smaller font size, margin and line spacing. Finally, I have tested the usability of the modified document. This research shows that the modification of typographic parameters and page layout of a document could save us paper and ink.

Keywords	green technology, sustainable printing, typography, paper and ink consumption

Contents

Abbreviations and Terms

AIGA (American Institute of Graphic Arts)

A professional association for design that is committed to advancing design as a professional craft, strategic tool and vital cultural force.

Font

A particular typeface with complete character set of a single style and size.

FSC (Forest Stewardship Council)

A nonprofit international organization which promotes the responsible forest management.

ISO (International Organization of Standards)

A non-governmental organization made up of a network of the national standards institutes of 157 countries, which all participate in the development of international market-driven standards for industry.

SGP (Sustainable Green Printing Partnership)

An independent, non-profit organization that provides a certification label for sustainability in the graphic communications industry.

Toner

Powder used in printers for the formation of printed text and images on papers.

VOCs (Volatile Organic Compounds)

Organic chemicals emitted from solvents, inks, and cleaners used in the printing process.

1 Introduction

In the 21st century we have witnessed a lot of innovations and technical modifications. On top of these technological advancements, organizations have been seen fighting on how to keep the balance of nature and reduce cost at the same time. These organizations are focusing on materials that have a considerable influence on the natural ecosystem if altered or consumed. Almost every manufacturing company consumes raw material from its surrounding, either directly or indirectly. Besides the resource consumption, manufacturing companies are disposing bad wastes to the environment that are threatening the long term survival of our species and planet as a whole. This disturbance of nature is the basis for the foundation of a new way of technological thinking, 'The green technology'.

Green technology, discussed in detail in the next chapter, can be termed as a new branch of technology that aims at transforming pre-existing technologies to go 'green'; this means minimizing or eliminating the consequences of material consumption and changing the way we use our resources. Organizations are trying to introduce this new concept to the society by teaching and creating awareness about the damage we are causing to our ecosystem. Climate and weather instability can be mentioned as one example. The environment's safety has a role in maintaining all living things inside its circle. As explained in chapter 2.1, the printing industry is one of the most environmentally polluting industries which discharge hazardous chemicals in to the atmosphere. As a result of these environmental issues, several techniques have been introduced to minimize the impact of pollution.

In my thesis I have modified the properties of the available typefaces such as font size and ink consumption together with the margin property of document layout in a way that can minimize the ink and paper consumption and achieve considerable cost saving while contributing to a sustainable printing strategy in general. I have also suggested some replacement options that can be implemented for the same purpose.

2 Going Green

2.1 Green Technology

Annually, approximately 90 billion tons of fossil fuel pollutants, such as CO_2, CO, SO_2, NOx, soot and ash are estimated to be spewed out into the atmosphere leading to the greenhouse effect, air pollution and acid rain. Also, five trillion US dollars are spent annually to recover from the damage caused by these pollutants to humans, to crops, to all flora and fauna and to man-made structures, in fact, to our entire environment worldwide. [1, 5] Green technology is a term used to describe an environmentally friendly way of approaching the way we use the technology; it is the means to bring an end to these pollutants that are harming the environment. In the department of Information Technology (IT) the term 'Green Technology' can mean the reduced environmental impact from running the technology itself; for instance IT devices such as computers, printers, monitors, keyboards, scanners, etc. [2, 1].

The characteristics of green technology can be categorized into three parts; its efficiency in energy consumption, its limitation to the right size for the job and its cost for the proper disposal of unwanted equipment. These days, technology manufacturers are competing to provide the lowest unit price to the market without realizing the long term impact that the equipment can have in the consumption of energy. Consumers as well must be aware of environmental issues and purchase a product that can effectively get the job done without any waste of energy. This is very beneficial for the customer as it saves money and the overall energy of our planet. Upon the expiration of a product life span, a proper disposal can benefit the manufacturer in recycling the product while minimizing the pollution of the environment. Every company has to take responsibility for the cleanup of its own products when the products are completely broken and declared useless by the consumer. [2, 2]

The printing industry is the third largest waste producer on earth; that is why there is a need for a sustainable business practice that are now shifting very quickly and positively. [3, 130] Modern offices are responsible for the production and waste generation of paper products along with a number of costs such as, papers, printers and copiers. Furthermore there is also a significant spending on the energy to power

them. The storage space of the paper documents and its cost for the disposal can add to these issues. Reducing the overall consumption of paper slows down the rate of the amount of trees cut down each year and indirectly reduces the amount of water needed for the production of paper. This will result in the minimization of the amount of waste materials added to the municipal waste streams. [2, 102]

Figure 1 . Life cycle approach to paper making. [4]

The figure above shows how the paper making industry can minimize the environmental impact throughout its development and production cycle by means of sourcing raw materials, use of natural resources, product performance, packaging and disposal of product after use.

2.2 Why Green Technology

The climate is not what it used to be, the weather condition of our planet is changing through time. Extreme weather events such as floods, droughts and storms which are the result of global warming are evidences for this change. Whether the change is

caused by human activities or is part of the natural process is still baffling scientists. However, many believe that the majority of the consequences are a result of human activities such as deforestation and various industrial and agricultural practices. [5]

The burning of coal, oil and natural gases as a source of energy is bad for the climate because they produce greenhouse gases, mainly carbon dioxide. Carbon dioxide is one of the greenhouse gases that contributes to the global warming of our planet. Fossil fuels are non-renewable sources of energy and can not be embraced inside the umbrella of the green technology. However, alternative non-fossil sources of energy have been introduced to the market and are operational now. Biomass (including waste), solar power (both photovoltaic and thermal), hydro, wind, wave, tidal and geothermal energy are examples of non-fossil sources of energy. The removal of carbon from the atmosphere is also possible through planting forests. [6, 10]

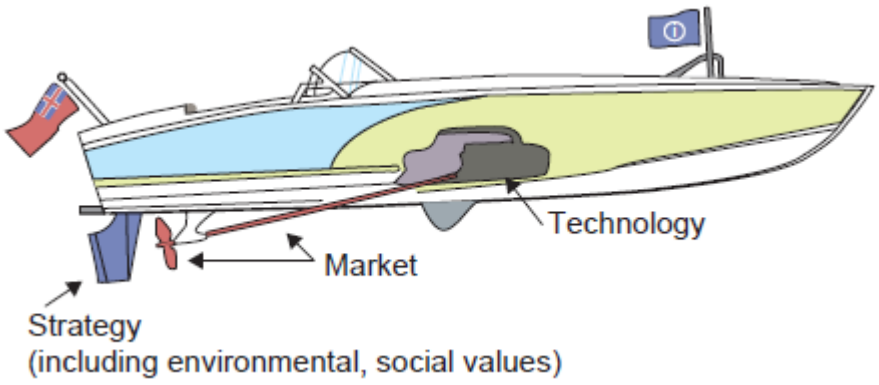

Figure 2. The boat flies national and UN flags to illustrate the need for national and international strategies. [6, 11]

Let's assume that we are taking a trip on the boat shown in figure 2 with all the technology, environmental and social values. The engine of the boat is the technology that forces the propeller, which is the market in this case, to be driven away. But without someone steering it with a specific destination and strategy in mind, the course will be arbitrary, if not disastrous. [6, 11]

The resources of the earth are finite but yet we are living beyond their ecological limits. We are living in a world where 20 percent of the population consumes 86

percent of the world's resources. A responsible act of consumption is what can save and determine our future survival. Socially and environmentally responsible businesses are our saviors. "Sustainability addresses these challenges by considering the social, environmental and economic dimension of each action to ensure they can continue indefinitely. These issues can be tackled by adopting a 'sustainability mindset'. This means taking your values to work and automatically incorporating sustainability concerns into your everyday thinking. Major businesses have realized that embracing sustainability makes excellent business sense by incorporating sustainability into business thinking. [7, 204-205]"

2.3 Sustainable Culture

Most of the time people mistakenly use the terms "green" and "sustainable" interchangeably and yet they do not actually mean the same thing. Sustainability goes beyond the 'greenness' of products to checking out whether they satisfy the needs of the present without sacrificing the needs of the future. For instance, the efficient energy consumption of a material might entitle it 'green' but not as 'sustainable' if the waste associated with it and the raw material it consumes are found to be degrading the environment and the resources available for the future. [8]

The characteristics and operations of sustainable cultural approaches can be listed as [9, xvii]:

- Environmental, social and financial focused design and development
- Efficient use of capital and market
- Efficient use of natural resources
- Waste, toxic reduction from the environment
- Focus on effective and efficient solutions for the society, the environment and the company

Figure 3 shows how sustainability can be managed with the combined effort of the three major factors we are facing today; economic, social and environmental factors.

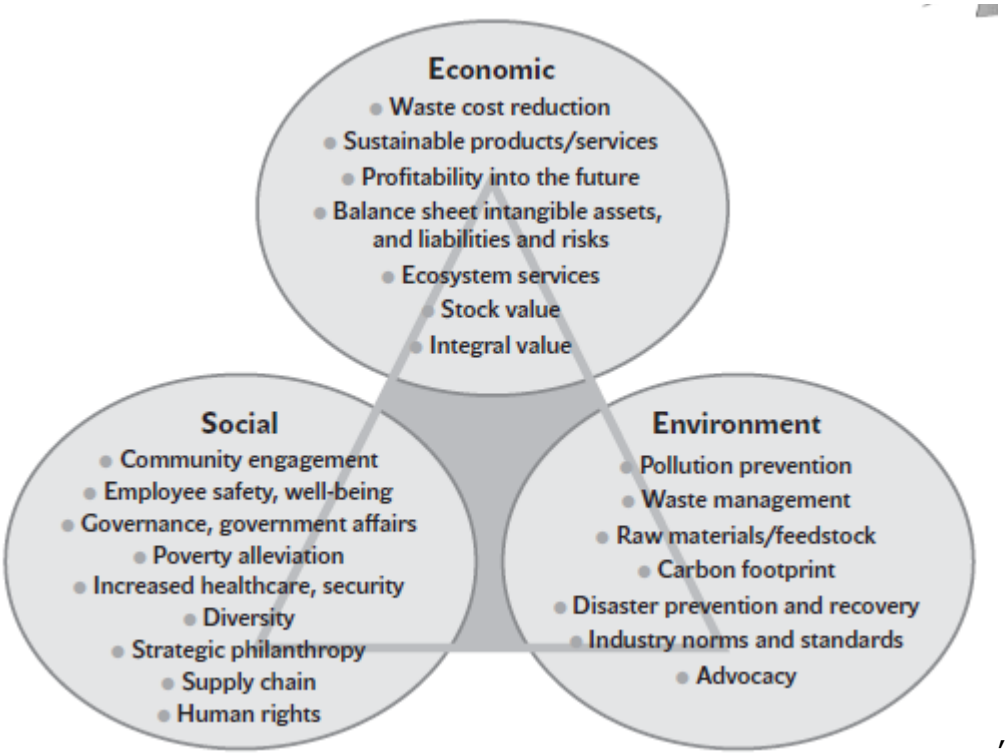

Figure 3. Total sustainability management model. [10, 93]

3 Green Printing

3.1 Overview of Sustainable Printing Technologies

Printing can be defined as a process in which an ink or a varnish from a printing plate is applied to a substrate through the application of pressure to leave an impression. Modern printing technologies such as inkjet printing work by spraying ink on to the substrate. The commercial printing industry classifies the production process into four main parts; offset lithography, gravure, letterpress and silk screen. All of these parts are distinct in their cost, production quality, production rate, and production volume. [11, 151]

The prepress, the actual printing process or the press, and the finishing process or the postpress are the three stages of the production stages of a print media. Figure 4 illustrates these processes in detail. Data flows between these individual stages of production such as the flow of printing plates between prepress and press, the flow of printed sheets between press and postpress. [12, 14]

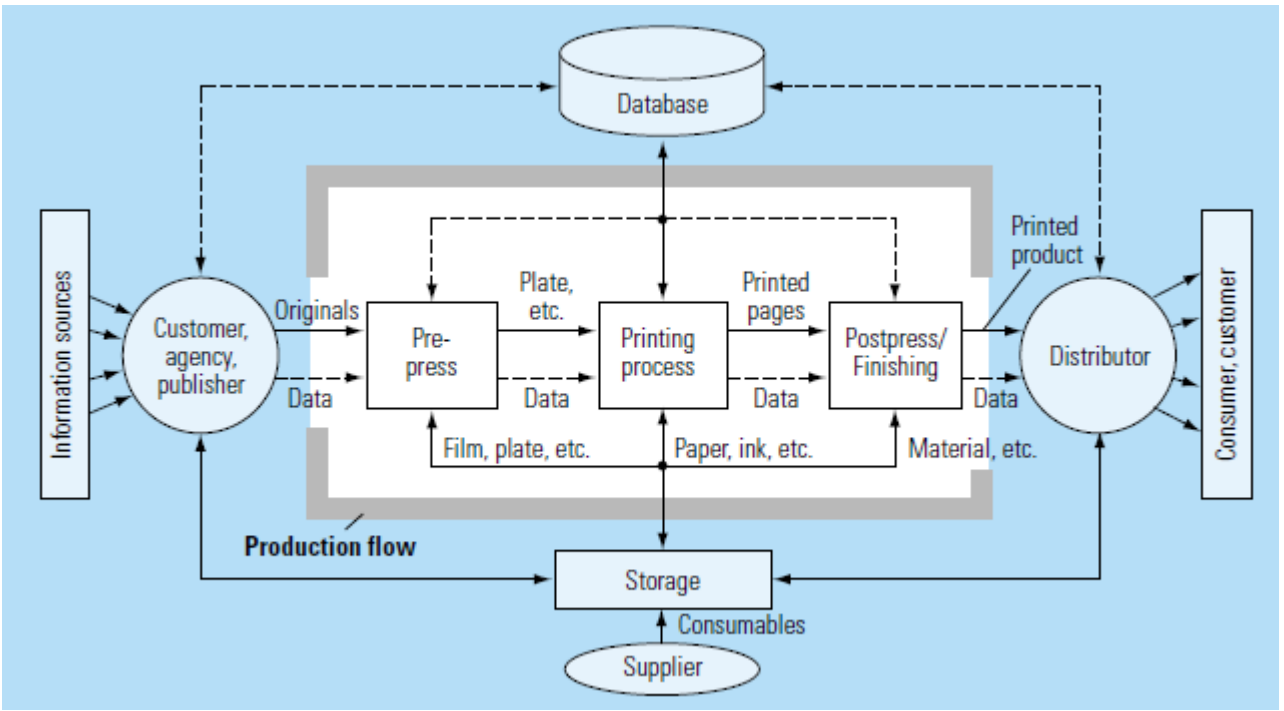

Figure 4. Production flow, material and data flow for print media production. [12, 14]

The quest to adopt sustainable production starts with printers. Printers are the mediums that connect designers, customers, complicated manufacturing and production processes. They are the means for the transmission of information and are responsible for maintaining a clean and efficient facility. Designers can help the printing industry to enjoy a sustainable production by making eco-friendly printers as their first choice. [13, 66]

As a human can not survive without food, a printer can not operate without sufficient energy. A fully energy powered printer needs paper and ink to do its job. Sustainable printing is all about the optimal use of these inputs to satisfy the needs of customers. Designers adopting sustainable printing in their businesses can be recognized as environmental friendly graphic designers. Looking for means to close the gap between sustainability and customers is the responsibility of the designer. Chapter 4.2 provides insights and tools that are meant to be useful for any designer concerned about this issue.

Digital printing and waterless lithography consume small amount of water when compared with other printing technologies. Waterless printing uses a specific temperature range to transfer ink to the substrate whereas offset lithography uses a chemical process that requires water and dampening solutions. Waterless printing is a kind of offset lithographic printing process that excludes the water used in conventional lithography. The complete removal of water results in a remarkable reduction in water consumption during the operation and also reduced Volatile Organic Compounds (VOCs) emissions on the press. Printers that switched to waterless printing have reported an increase in their productivity by more than a 100 percent. In addition, adopting a waterless printing is cost effective. Digital printing, on the other hand, is considered environmentally suitable for signage, banners and for all the printing jobs that demand less than 2,000 units of copies. The environmental friendliness of a digital printing lies on its VOCs emission and its toner ink alcohol exclusion. [13, 74-75]

3.2 Typography and its Parameters

The history of culture in many departments has been highly influenced and is now in existence because of the introduction of three elements; type, typography and graphic design. It is with these tools that we know what has happened in the past and how the

future will look. Symbols are the basic building blocks of languages and a medium for the transfer of knowledge from generation to generation. These three elements are entangled one another: type being the crucial element of typography and typography in turn being the crucial element of graphic design. [12, 14-15]

Typography is dependent on type. Typefaces determine the way how the type looks in its various forms. The design of printed text using typefaces to create continuous text on a printed page is called typography. Figure 5 illustrates the anatomy of typefaces. Designers are not tied or limited with certain types of rules when making their type selection. The selection is entirely dependent on approximation gained from own experience. After the selection of a particular typeface or font, a designer adjusts the different characteristics or properties of the font for the various parts of the text. The font properties include: [12, 19]

- Font size
- Font type style (e.g., light, regular, or semi-bold)
- Font inclination (e.g., normal or italic)
- Font color and style (e.g., upper case, lower case, mixed)

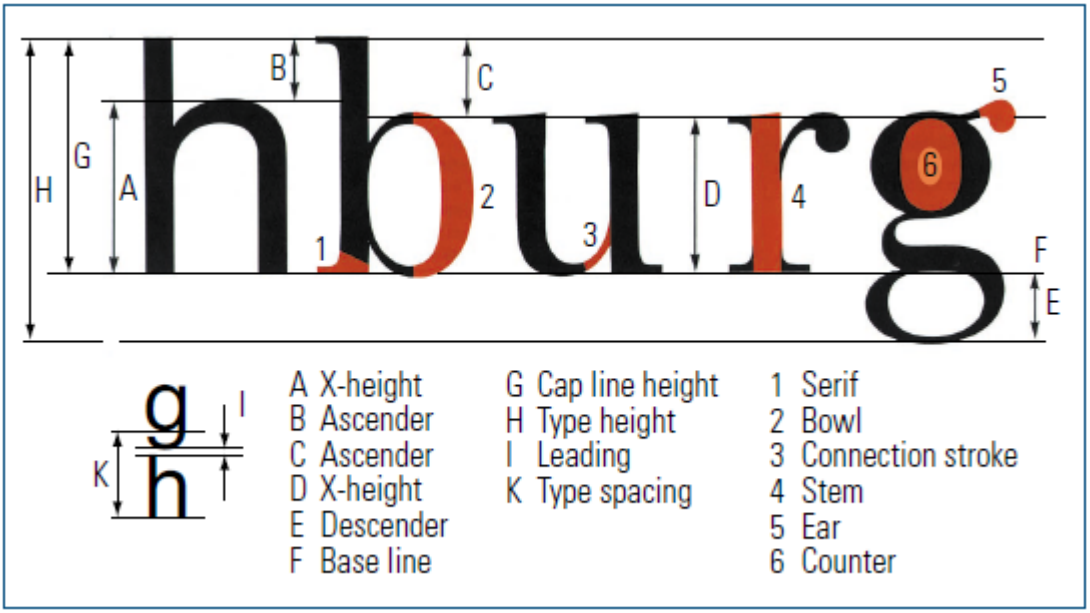

Figure 5. Anatomy of typefaces. [12, 17]

After adjusting the characteristics of the fonts, a designer establishes the text structures which include: [12, 19]

- How far apart the individual lines are
- What degree of line spacing (leading) there will be
- What column width should be set
- Which justification will be selected (justified, unjustified, and centrally justified)
- Whether each of the text paragraphs is to have an indent.

According to the Handbook of Print Media (Kipphan 2001) "A few of the recommendations for good, legible typography indicate what the basic problems of design are: there should be a maximum of around 60 characters per line and around 40 lines per page. Lengthy texts should be set no smaller than 9 point and no larger than 11 point. The leading (line spacing minus size of type height) should be 2 point. [12, 19]"

There are certain types of design principles that must be followed by any graphic designer in order to produce a good result. So as to avoid design pitfalls, a graphic designer has to be aware of the overall nature of the design and for whom it is meant for. These rules-of-thumb can be categorized into five different parts; audience, layout, typography, image and color. A close and effectively addressing of the target audience is the first step a graphic designer has to focus on prior to engaging to layout design. The age of the target audiences vastly affect in how the layout should be designer. For instance, kindergarten-first graders might find it difficult to distinguish and comprehend small prints. Knowing the need of the target audience will help the designer to present the design so that the audience best receives the message presented.

In order to grab the attention of the audience the layout has to be informative and have a guiding force to take the user throughout the content even if the content is not interesting. For instance dropping shadows on the borders of images and boxes can draw attention to the information provided. Typography is all about legibility and readability of content. Mastering the art of typography takes the designer a step further in developing a deeper understanding of what it takes to deliver the audience the best quality content. [14]

3.3 Paper and Vegetable-based ink

Finland is a highly industrialized country and the third largest paper manufacturer in the world. Together with Germany, Finland is a world leader in paper recycling and its recycling culture is among the oldest practices accustomed by a country. The raw materials for printing papers, soft tissues and packing boards have been reported to come from the recycled paper and cardboard. In 2004, 1.1 million tons of paper was consumed in Finland, representing approximately 214 kg/person. Of this, 71 % (i.e. 0.8 million tons) was recycled. Municipal waste constitutes 4% of the total waste of Finland between 1997 and 2008, two third of which was reported to arise from households. The largest component of a municipal waste is of paper and paperboard products. [15] Figure 6 displays the total amount of municipal waste in Finland from 1997 up to 2008 in tons.

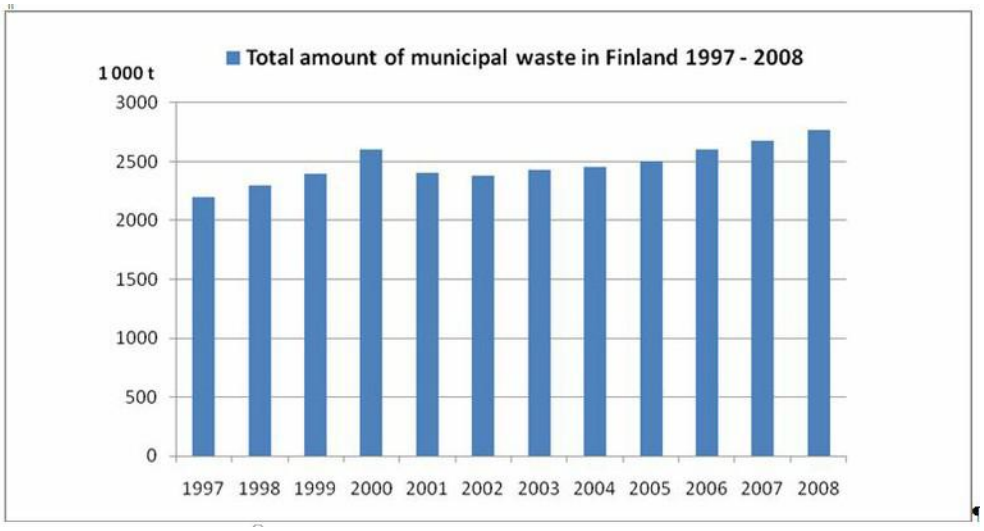

Figure 6 . Total amount of municipal waste in Finland 1997 - 2008. [15]

The paper production industry takes the 4th place of all the manufacturing industries in energy consumption globally. It is also one of the dirtiest to generate air and water pollutions besides solid wastes. Today, 30 percent of the municipal landfill is declared to come from paper and 75 percent of which end up in the trash within a year. The global appetite for paper products is rising in low and middle-income countries that have historically used less paper than the developed world. The rapid growths of e-commerce and digital delivery systems have not decreased the consumption of paper.

Working with paper products that are environmentally preferable and printers that are eco-friendly can significantly boost the effect that a graphic design has on the planet. [13, 40]

Discontinuing the use of fiber that comes from organic sources might not be a solution for a sustainable forestry. A recycled waste paper can not satisfy the global demand currently. Forest products from virgin sources will continue to be on demand in the future. [13, 44] Reducing our paper consumption by changing our previous habits can make a difference; that is what the topic of this thesis is about, character and layout modification.

Fiber, water and energy are the fundamental elements of paper-making process and in the meantime they are also the key factors that determine the paper's environmental impact. The main ingredient of paper that is used for printed communications is a wood fiber. A wood fiber is introduced with a variety of surface treatments like starch, latex, clay and dyes to determine its color and brightness. [16, 126]

To harness the use of sustainable printing, designers can adapt to the following guidelines.
Fiber issues [16, 128]:

- Use post-consumer recycled fiber
- Use sustainably harvested virgin fiber
- Use tree-free alternative fibers

Water issues [16, 134]:

- Use process chlorine free and totally chlorine free fiber
- Support closed-loop pulp and paper mills
- Use post-consumer recycled fiber, this requires a lot less water

Energy issues [16, 136]:

- Use post-consumer recycled fiber, this requires a lot less energy
- Support renewable energy sources in paper making

The printability of a paper can be affected by characteristics such as its smoothness, absorbency, opacity, and ink holdout. Designers have a variety of paper stocks to choose from. [11,115] Paper documents come in many different sizes, including (in inches) 8.5 × 11, 11 × 17, 17 × 22, 22 × 34, and 34 × 44. According to Webber (2009), "The International Organization for Standards (ISO) has created a standard paper size system specifying a number of formats. The most common formats and their uses are [2, 106]:"

- A0, A1 – technical drawings, posters.
- A1, A2 – flip charts.
- A2, A3 - drawings, diagrams, large tables.
- A4 - letters, magazines, forms, catalogs, laser printer and copying machine output.
- A5 - note pads.
- A6 - postcards.
- B5, A5, B6, A6 – books.
- B4, A3 - newspapers, supported by most copying machines in addition to A4

Figure 7 displays international paper sizes that are used as ideal resource in looking up a variety of paper standards for those working in graphic design, illustration, printing, export and packaging. [17]

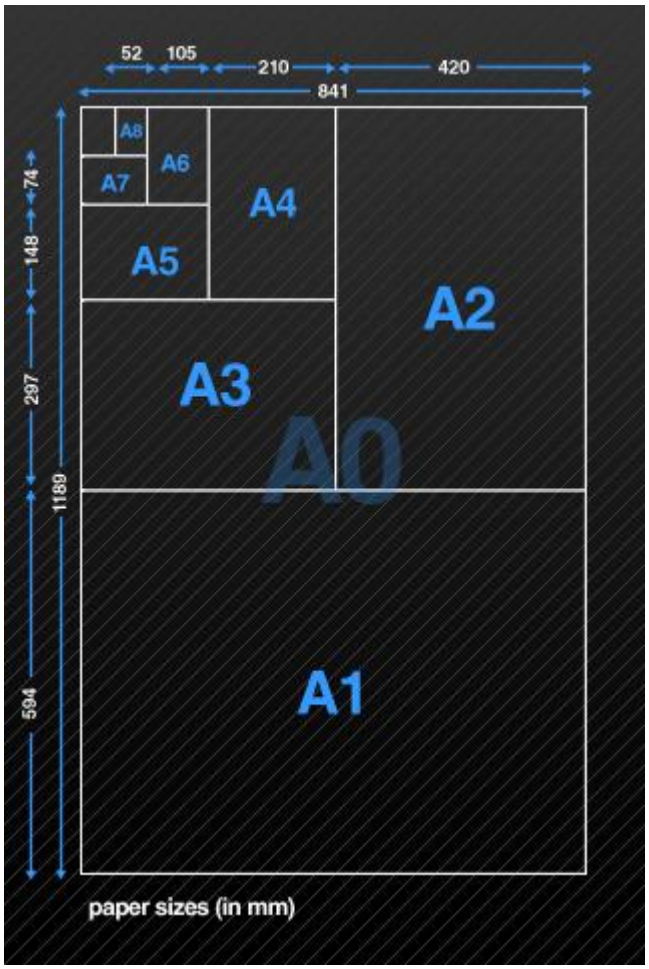

Figure 7. International paper sizes. [17]

Inks used in printing are made up a combination of pigments, binders and a vehicle which serves in holding and carrying the pigment. Binders help the pigment to stick to the paper. [13, 70] Petroleum oil has been the source of printing ink before vegetable ink was introduced to the market. Vegetable based ink is made of vegetable oil such as soybean and corn oils. The side effects of using traditional petroleum based inks are the following [18]:

- Heavy metals such as barium, copper and zinc that are contained inside petroleum based inks can contaminate soil and water.
- They emit more volatile organic compounds (VOCs) into the air. These organic compounds invoke respiratory conditions such as emphysema, bronchitis and asthma.

- It is hard to remove petroleum based inks from paper.
- Recycled papers that are derived from petroleum based inks are of low quality.

The benefits of using vegetable inks are listed below [18]:

- They are produced from renewable resources.
- Emit significantly fewer VOCs.
- Less toxic and easier to remove from paper hence facilitate recycling and derive high quality recycled paper with less hazardous waste.
- Produce brighter colors that can yield more impression, therefore less ink consumption during printing.

Printed products produced using vegetable inks look similar to ones produced with mineral oil based inks, but give advantages as explained above. Figure 8 displays a book printed with vegetable oil.

Figure 8. Book printed with vegetable inks. [11, 162]

4 Sustainable Printing

4.1 Introduction to Sustainable Printing

Sustainability can have a lot of definitions but the simplest way to define it is as a balanced use of natural, social, and economic capital for the existence of our planet and the coming generations. Designers have a lot of work to do so as to contribute and adapt the sustainable practices at a variety of levels: even the professionals have yet to find the perfect balance of our economic needs with the needs of the planet. [13, 12] According to Dougherty (2008), "The word 'sustainability' can apply to any action that does not degrade the systems supporting it, and therefore can persist indefinitely. [16, 28]" The next diagram in figure 9 shows where sustainability is embedded by focusing on our key demands.

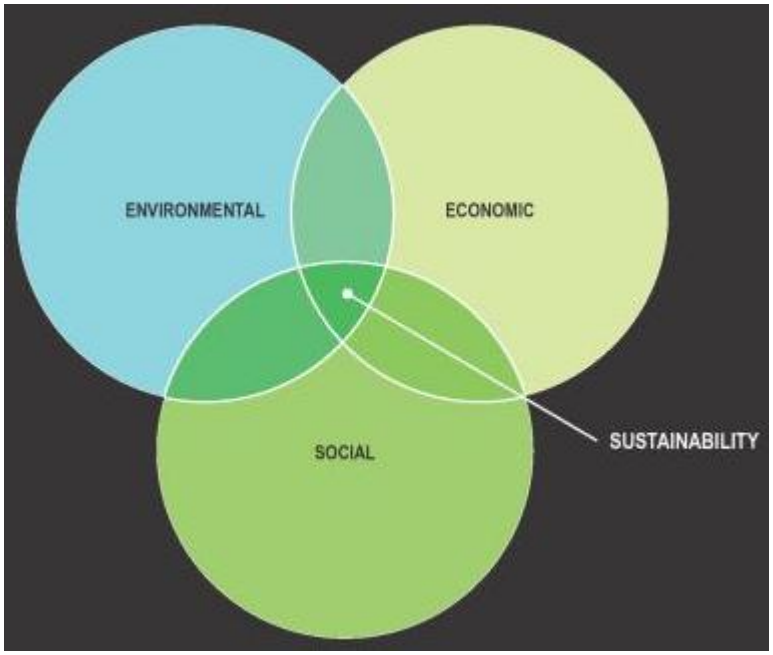

Figure 9. Sustainable design. [13, 12]

An organization called Sustainable Green Printing (SGP) Partnership, divides the sustainability considerations of graphic communication industry into three parts; product, process and envelope. This organization has a stated mission that says "to encourage and promote participation in the worldwide movement to reduce environmental impact and increase social responsibility of the graphic communications

industry through sustainable green practices" [8]. The 'product' part of the sustainable consideration includes the design aspect and input material used in production. The 'process' encompasses all the manufacturing steps involved in converting the raw material into a finished product including the waste produced during the production process. The last sustainability consideration, the 'envelope', includes all activities that support the manufacturing process such as buildings, grounds, utilities and the health and safety of employees. [8]

4.2 The Sustainable Graphic Designer

Nowadays the concept of sustainable printing is becoming a hot topic in the field of printing. The horizon of the topic has widened to a point that even consumers are willing to make a difference for the good of our planet. The responsibility of a sustainable graphic designer lies up on the optimal use of the tools he relies on; which are basically paper and ink. Making sure that both the papers and inks used are 'sustainably' should be the first step performed by any sustainable graphic designer.

The ultimate sustainability of a product is determined mainly by its design and input material choices. The sustainability of a job can further be improved by a detailed discussion about the product with the customer so that a variety of factors can be evaluated. The principles of environmentally responsible print design by the American Institute of Graphic Arts (AIGA) accommodates the following key factors: [8]

- Designing products that use less material and energy
- Recyclability, reusability and recoverability of the designed product
- Less toxic and environmental impact material selection
- Selection of lower impact packaging
- Product design that use less energy and water with less waste impact
- Product design aimed for a longer life span

4.3 Adapting Sustainable Printing

For designers, adapting a sustainable printing strategy might at first seem to take a long way; but understanding its importance can be used as a means to fuel our passion in reaching our goals in a short period of time. The printing process by itself is vast; from paper and ink production to printer manufacturing. While thinking of adapting a sustainable printing in your business, you need to take all these distinct features of printing in mind and ask if sustainability is part of the process. As Shedroff (2009) states, "Ultimately, sustainability is most powerful when it becomes part of an organization's values and mission, but we don't need to wait for this to begin in order to have an impact now. [9, xxiii – xxiv]"

In order for a company to adjust to sustainable printing, I assumed the following key questions need to be attached together with the strategic business plans.

- Are the employees, clients and partners aware of the values, mission and power of sustainability?
- Are we leading an environmentally conscious printing practice?
- Do we have eco-friendly based customers, and how do we attract them if not?
- Are we using recycled or FSC certified papers and vegetable oil based inks for printing? And what is going to happen to the paper after use?
- Are we using eco-friendly printers, if not why not try one?
- Are we responsible for the maintenance of our products and services for our customers?
- Where is the energy that we use to power our production coming from? Is it a renewable energy that can reduce greenhouse gas emissions?
- Do we have environmental graphic designers that have the potential to improve their environmental footprints while satisfying the needs of our customers?
- Are we teaching our clients to use our products without affecting their environment?
- Do our production distributions follow the principle of a sustainable packaging system? How about the efficiency of the transport?

Print businesses that adapt sustainability program have improved profitability as a result of waste reduction and the awareness of inefficient business practices. Environmentally conscious consumers are now growing in number and turning their face to print companies that have a sustainable approach in their framework. Governments have a positive attitude towards green-tech based companies; hence adapting one can reduce the risk of confliction with government regulations. The adaptation of a sustainable culture is beneficial in times when resources are scarce or expensive. Sustainable print businesses have satisfied employees which in turn results in improved company reputation. [8]

The wave of a sustainability movement is already in the air just like the personal computer revolution in the 1980s and the rise of modernism in the 1930s.The 'green' transformation has already been operational in architectural and industrial designs. Almost every graphic designer is expected to turn into a green designer within the next ten years. [16, 21]

5 Road to Sustainable Print

5.1 Reducing Ink Consumption

In the world of printing technology, many researchers have tried a variety of techniques to reduce the amount of ink and toner usage. These researchers focus on experimenting with fonts to better reduce their high amount of ink and toner consumption. But recently there was a new finding in Netherland in a company called Spranq. This company has conducted a unique approach to reduce the expenditure of ink and toner through the modification of pre-existing fonts. This new approach was implemented by using newly made software from the company called the Ecofont. This software operates by creating holes on a given font. The fonts tested on were those fonts what we use daily and are familiar with the computer technology; such as, Arial, Times new roman, Verdana, Calibri and Trebuchet Ms. Custom fonts were also manufactured by the company like the Ecofont Century Gothic which is the Ecofont version of Century Gothic and the Ecofont Vera Sans which is the Ecofont version of Vera Sans. The Ecofont software shots holes into characters; these holes are created with a purpose to save ink and toner consumption and are neither visible on a computer screens nor on a printed paper.

During its five-year plan to go green, the University of Wisconsin-Green Bay has claimed a 30% less ink consumption that costs up to 10,000 dollar per gallon when it changed the default font for its email from Arial to the less-ink intensive font, the Century Gothic. The university was aware of the fonts from Ecofont but rather they reported that the full version of Century Gothic was more efficient in doing the job [19].

A Dutch company called Printer.com did a research and demonstrated that we can save up to 31% on our ink cartridge costs just by picking the right font by comparing the ten most frequently used typefaces on a Canon inkjet and a Brother laser printer (both set at 600×600 dots per inch). According to the blogging site 'blog.printer.com' on a title 'Printing Costs: Does Font Choice Make a Difference?' (2009), it was stated that "Century Gothic is a modern font that comes as a standard with MS Windows. Surprisingly, it even beat Ecofont which was specifically designed with efficiency and cost in mind. For those who require a more "traditional" look, Times New Roman

provides a good balance between style and savings. [20]" The table below displays the details of the research by Printer.com.

	font	size	coverage	private cost	business cost
1	Century Gothic	10	3.45%	$46.32	$179.29
2	Ecofont	10	3.47%	$46.59	$180.33
3	Times Roman	11	3.54%	$47.53	$183.97
4	Calibri	11	3.81%	$51.16	$198.00
5	Verdana	10	4.55%	$61.09	$236.45
6	**Arial ***	**11**	**4.97%**	**$66.73**	**$258.28**
7	Sans Serif	11	5.09%	$68.34	$264.52
8	Trebuchet	11	5.12%	$68.74	$266.08
9	Tahoma	11	5.21%	$69.95	$270.75
10	Franklin Gothic Medium	11	5.51%	$73.98	$286.34

Table 1 . Details of the research by Printer.com. [20]

A company called Inkfarm.com provides products for printers and fax machines such as; ink and toner cartridges, laser drums and maintenance kits, printer and fax ribbons, photo and special papers for printers and printer cables.

The online ink-usage calculator at Inkfarm.com can be used to calculate the total savings that can be achieved by comparing the ink consumption of two fonts at a time. Since the font type of the current Media Engineering thesis guideline at Metropolia University of Applied Sciences is Tahoma with a font size of 11 point, the comparison in spending if it was switched to Century Gothic was calculated to come up with the result as shown in figure 10. Since Century Gothic has a relatively wider font than Tahoma, a font size of 10 point was chosen for comparison.

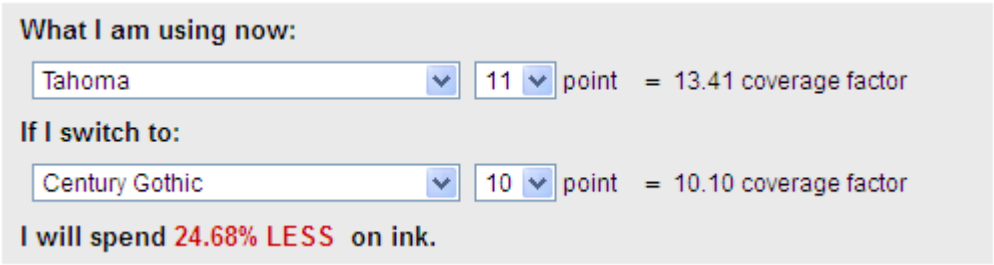

Figure 10. Screen shot taken from Inkfarm.com. [21]

Next, the comparison was between Tahoma and Times New Roman, both with a font size of 11 point. The result is shown in figure 11. The reason why Times New Roman was chosen for the test was because of its relative small font size to Tahoma and Century Gothic.

Figure 11. Screenshot taken from Inkfarm.com. [21]

Choosing from the different font types available with a certain modifications might not be the only option to save ink and paper. The printer driver entitled 'ecoPrint2 Pro Ink and Paper Saver' from Ecoprintsaver.com claims to cut ink consumption by three-fourths. This driver allows the user to control the amount of ink to be used and offer options for the arrangement of the paper to get the most out of the resources available. The driver can be used with any printer as well as printers shared over any Local Area Network (LAN). This same company has another discreet background application which is called 'ecoPrint2 Ink and Toner saver' that can reduce up to 75% of ink usage.

Let's say we are using currently an Inkjet printer with ecoprintsaver's printer driver in our office. If we assume there are 40 staffs and calculate our total ink and paper savings with the ecoprintsaver's online Environmental Impact Calculator, we will come up with the result as shown in the figure below.

Figure 12. Screen shot taken from ecoprintsaver.com. [22]

Cost Calculation Values and Sources of the online Environmental Impact Calculator are explained as follows:

Annual Paper Usage = (number of people in office) × (20 sheets of paper used per person per day)* × (220 days per business year)

Annual Paper Cost = (Annual Paper Usage) × ($0.016 per sheet of paper)†

Annual Color Ink/Toner Cost = (Annual Paper Usage) × (cost of color ink/toner used per sheet of paper)§

* The average person uses about 10,000 sheets of paper a year (i.e. between 20-50 sheets of paper a day), based on research by Reduce.org

† Average cost of one package of 500 sheets of paper is about $8.00, therefore cost per sheet = $8.00 ÷ 500 sheets = $0.016 per sheet

‡ The average commercial use laser black toner cartridge costs about $210.00 and can print around 4,750 pages of just black and white documents, so the cost of black laser toner per sheet of paper printed = $210.00 ÷ 4,750 sheets of paper = $0.044 per sheet The average commercial use black inkjet ink cartridge costs about $330.00 and can print around 10,000 pages of just black and white documents, so the cost of black inkjet ink per sheet of paper printer = $330.00 ÷ 10,000 sheets of paper = $0.033 per sheet .

§ The average commercial use laser color toner cartridge costs about $158.00 and can print around 4,750 pages of just black and white documents, so the cost of black laser toner per sheet of paper printed = $158.00 ÷ 4,750 sheets of paper = $0.033 per sheet.
The average commercial use color inkjet ink cartridge costs about $330.00 and can print around 6,000 pages of just black and white documents, so the cost of black inkjet ink per sheet of paper printer = $330.00 ÷ 6,000 sheets of paper = $0.055 per sheet .

‡ and § are based on research by Activewave Interact, Inc.

With a 50 percent ink use reduction and a 2-up paper saving setting for inkjet printer, it was possible to save over $13,000 a year using ecoPrint2 Ink and paper saver. 2-up means 2 pages on one side of a sheet of paper. The result from the calculation is displayed in the figure below.

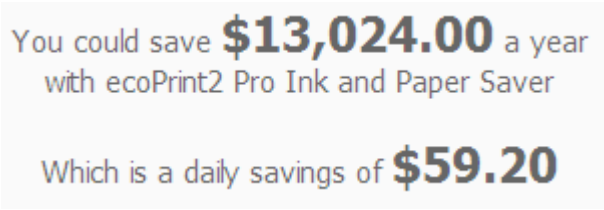

Figure 13. Screen shot taken from ecoprintsaver.com. [22]

Figure 14 shows the total annual savings we can achieve with a laser printer with the same input criteria as used for the inkjet printer above.

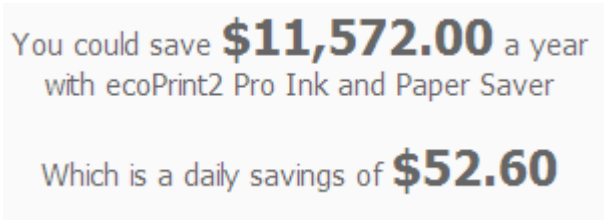

Figure 14. Screen shot taken from ecoprintsaver.com. [22]

There is also software that has a positive online reputation that is used for a specific level of ink reduction (0-75%) that can be determined by the user that claims to cause cartridges to last longer. InkSaver 2.0 is the first printer improvement software product. This application operates as a buffer between the computer application and the printer.

The next figure shows how much money InkSaver can save. The descriptions are self-explanatory.

Average # of pages you print per week:	1 cartridge should last*:	Cost of cartridges per year:	With InkSaver set at 50% you can save:
75 pages/week	4 weeks	455/year	**Save $225/year!**
50 pages/week	6 weeks	300/year	**Save $150/year!**
20 pages/week	15 weeks	120/year	**Save $60/year!**

Figure 15. Money saved per year with a 50% ink reduction using InkSaver 2.0. [23]

The COSTDOWN SIMULATION online application from InkSaver is used to calculate how much can be saved with a particular input field.

Let's assume the following statements holds true:

- Assume that 40 students will graduate in media engineering every year
- Assume the number of pages for thesis papers on average is 50
- Assume out of the 50 pages 8 of it is printed in color
- Assume every student prints 4 copies of thesis paper; one for the supervisor, one for the technical reading teacher, one for the library and one for him/her self.

Let's feed this information into the online costdown simulation application from InkSaver and see how much we can save per year if InkSaver 2.0 is in effect. The following figure illustrates the actual form from their website with our data in place.

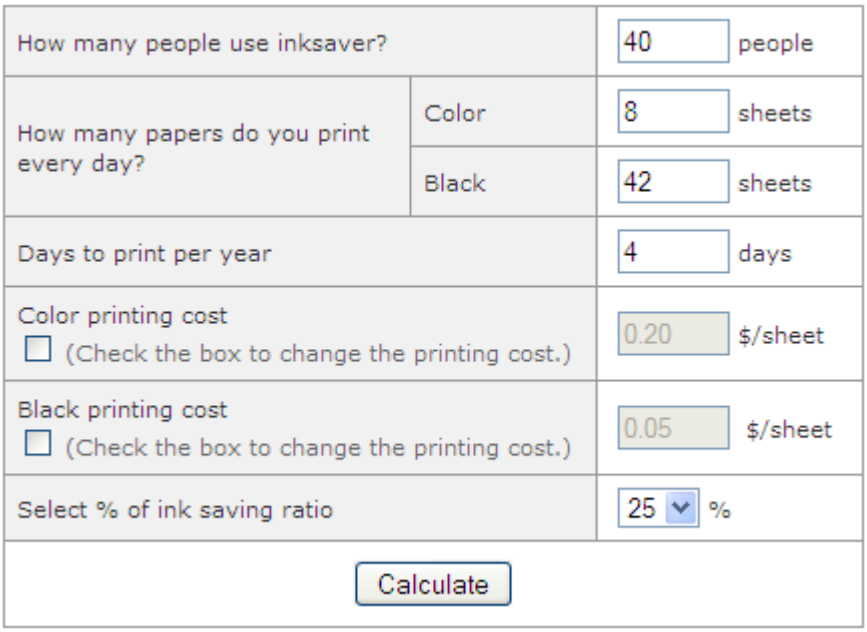

Figure 16. COSTDOWN SIMULATION form. [23]

With a 25% ink saving ratio, the annual cost of ink saving was $148. Figure 17 and figure 18 displays the average cost saving in printing after the calculation with an ink saving ratio of 25% and 75% respectively.

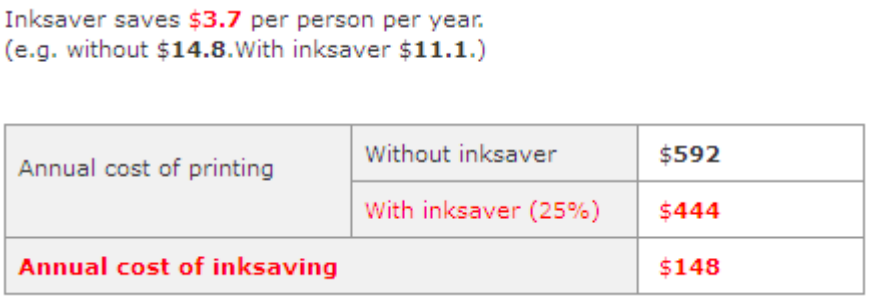

Figure 17. The calculated result. [23]

If the percentage of ink saving ratio is increased to 75% we can save up to $444 per year.

Inksaver saves **$11.1** per person per year.
(e.g. without **$14.8**.With inksaver **$3.7**.)

Annual cost of printing	Without inksaver	**$592**
	With inksaver (75%)	**$148**
Annual cost of inksaving		**$444**

Figure 18. The result, with 75% ink saving ratio. [23]

5.2 Reducing Paper Consumption

Designers have a wide range of font options to choose from. But most of them are not of how much ink and physical space the fonts consume. However, when thinking about leading a sustainable printing practice, the choices have to be made wisely. Reducing the consumptions of our environmental resources is the key concept here. In this thesis research, paper and ink consumption is the main focus of the topic. Only those typefaces that are ink economical and only those fonts that has smaller paper space consumption have been chosen for the comparison and evaluation.

The implementation of the Ecofont software and its custom fonts is open to the choice of any company who wants to benefit from it. Therefore, I would like to leave it as a strong recommendation to whoever wants to practice with it. Most desktop word processing applications support font types like Tahoma, Century gothic and Times new roman. These fonts are available for free and are among the most commonly used fonts by consumers and professional designers. The fonts' property of economical ink consumption, as illustrated in Table 1 in chapter 5.1, was the reason why they have been set to be tested to compare their paper space consumption. By applying the same font specification as was used to calculate the ink consumption of the typefaces as illustrated in figures 14 and 15, the test was conducted. Table 2 explains the properties incorporated in this test case.

No	Font Type	Font Size (px)	Line Spacing	Text Align
1	Times New Roman	11	1.5	Justify
2	Century Gothic	10	1.5	Justify
3	Tahoma	11	1.5	Justify

Table 2. Font property details.

The next page is dedicated to illustrate the differences of the three font types shown in the table above for their paper consumption using the properties as stated.

(1)

"Here are highlights from the Code of Ethics of the Society of Graphic Designers of Canada (gdc). These same clauses are mirrored in the Rules of Professional Conduct of the Association of Registered Graphic Designers of Ontario, and thus became linked to the laws of Ontario: A Member, while engaged in the practice or instruction of graphic design, shall not do or fail to do anything that constitutes a deliberate or reckless disregard for the health and safety of the communities in which they live and practice or the privacy of the individuals and businesses therein. Members shall take a responsible role in the visual portrayal of people, the consumption of natural resources, and the protection of animals and the environment. [3, 160]"

(2)

"Here are highlights from the Code of Ethics of the Society of Graphic Designers of Canada (gdc). These same clauses are mirrored in the Rules of Professional Conduct of the Association of Registered Graphic Designers of Ontario, and thus became linked to the laws of Ontario: A Member, while engaged in the practice or instruction of graphic design, shall not do or fail to do anything that constitutes a deliberate or reckless disregard for the health and safety of the communities in which they live and practice or the privacy of the individuals and businesses therein. Members shall take a responsible role in the visual portrayal of people, the consumption of natural resources, and the protection of animals and the environment. [3, 160]"

(3)

"Here are highlights from the Code of Ethics of the Society of Graphic Designers of Canada (gdc). These same clauses are mirrored in the Rules of Professional Conduct of the Association of Registered Graphic Designers of Ontario, and thus became linked to the laws of Ontario: A Member, while engaged in the practice or instruction of graphic design, shall not do or fail to do anything that constitutes a deliberate or reckless disregard for the health and safety of the communities in which they live and practice or the privacy of the individuals and businesses therein. Members shall take a responsible role in the visual portrayal of people, the consumption of natural resources, and the protection of animals and the environment. [3, 160]"

It is obvious that the previous page has shown Times New Roman to take up the smallest paper space to the rest of its competitors. The 'How readable is it?' is the only question that is left now. The analysis and result have been explained on chapter 6.2.

5.3 Replacement Options

As Velte et al. (2008) state, "Being completely paperless might be a pipe dream. People just like to hold paper. That's why newspapers and magazines—despite having a web presence—are still printed and sold. [24, 103] " Some of the advices I presented as a replacement options might not be 'sustainable printing' friendly; however they have the potential to achieve a sustainable environment.

The following 'What if we all' statements that I come up with are meant to spark a question on each of us; in the meantime, given a strong consideration, they can vastly alter our previous culture of ink and paper consumptions.

- What if we all edit, save and share some of our documents in an electronic media till it is necessary that we need them in print
- What if we all print draft documents with black or grayscale or use a draft mode of printing for a significant reduction on ink consumption
- What if we all are aware of the printer's built-in settings that have the potential to save us on ink consumption
- What if we all are aware of the word publishing applications that allow us to alter the layout format of the document for means to save us on paper consumption
- What if we all print multiple pages per sheet as long as the text is readable
- What if we all use both sides of the sheet when printing documents

In their book on Implementing Sustainable IT solutions (2009), Webber and Wallace claim that "The portable computing devices available today, such as tablet PCs, PDAs, and cell phones, are still not easy enough to use to totally replace paper. The older generation of workers has an almost emotional attachment to paper, as it is what they grew up with. As better electronic devices become available and the workforce shifts to

a generation raised with electronic devices, the need for paper is sure to decrease. Until that day comes, a number of practices can be encouraged to dramatically reduce the amount of paper used in the modern office. [2, 103]”

Sustainable printing is all about environmental awareness, the impact a printing task can bring about. We do not have to leave the entire load for the designers since the effect of uncontrolled printing habits can affect our environment and all of us. It is a well known fact that self responsibility is the key to success and this principle also holds true for our fight to minimize the consumption of natural resources; resources like paper and ink when in printing sustainably. Every individual, students and workers, the employed and the unemployed, all of us that are directly or indirectly involved in print related tasks must be aware and be responsible about our daily ink and paper consumptions. We do not have to do it just because we can save money; but we have to know that at the same time we are saving our planet.

6 Usability Test and Analysis

6.1 Current and Modified Media Engineering Thesis Guideline

The modification of the current thesis guideline has focused on core typographic parameters and document layout properties that were particularly thought to reduce the amount of paper used for printing. The margin (T x L x R x B) represents the top, left, right and bottom margins respectively. The table below illustrates the formatting options with their values for both the current and modified thesis guidelines.

Formatting option	Original	Modified
Typeface	Tahoma	Times New Roman
Spacing	1.5	1.5
Paragraph Spacing	line	line
Size	11	11
Margins (T x L x R x B)	2.5 x 4 x 2 x 3	1 x 1.5 x 1 x 1
Number of pages	44	37

Table 3. Formatting options with their values.

As Table 3 reveals, it was possible to save 7 pages from the original 44 pages which is a 16 percent paper saving through the modification of the formatting options

presented. This result holds true for a one-sided thesis printing. A significant print paper reduction can be achieved if papers go through a two-sided printing process, meaning if both sides of the sheet of paper is used when printing. Adapting this kind of printing process will increase the paper saving percentage to a 60 percent.

6.2 Analysis of the Usability Test

A usability test for the modified version of the media engineering thesis was conducted on October 31, 2011, by three students of Metropolia inside the University. The purpose of the test was to determine whether users can easily read the text we provide them. Twenty participants were chosen for the test their ages ranging from 20 to 70. Each participant was given a sheet of paper full of texts; at the bottom of the test paper there were two tick boxes they have to mark which were labeled as 'Readable' and 'Not readable'.

According to Barnum (2011), "The best-known definition of usability is the one from ISO, the International Organization for Standardization (9241-11): 'The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.' [25, 11]" Simplicity affects the usability of things and most designers and developers are using this principle when manufacturing and supervising their products. In this scenario, the simplicity might apply to how readable the content is. If the users are able to read the text without any problem after taking away or modifying some features that were incorporated on the current media engineering thesis paper, then it can be concluded that the goal of this thesis has been achieved. Furthermore, the recommendations for good, legible typography that were presented on page 14 were found to fit perfectly for the modified version of the thesis guideline.

The different facets of a user experience can be best described with a honeycomb diagram as shown in figure 19. Using the honeycomb as the basis for the usability test, the 'accessible' part has been chosen to determine what to learn from the users when conducting the test.

Figure 19. The facets of user experience are presented as the user experience honeycomb. [25, 13]

Readability can be one property of accessibility in this test case scenario. Upon completion of the test, an overview of the final result indicated that none of the participants ticked the 'Not readable' box. The result of the analysis was very satisfactory for me and I hope it will benefit the University if implemented. A comparison on the readability of texts based on the current and the modified thesis guideline results in no significant difference.

7 Conclusion

How the world treats the next generation strongly depends on how friendly and peacefully the current generation is living with nature. Uncontrolled way of resource consumption and waste disposal has a long-term side effect for our future life. "Our shared commitment to creating a more sustainable world, especially ensuring that the world is livable for our children, grandchildren, and generations to come continues to fuel our passion and unite us. This is consistent with the basic and most widely used definition of sustainable drawn from the Brundtland Commission (World Commission on Environment and Development, 1987), 'meeting the needs of the present without compromising the ability of future generations to meet their own needs.' [10, 2]"

Nowadays companies are implementing a lot of methodologies to efficiently consume the scarce resources by providing an alternative option for their products. Environmental sustainability has raised questions and awareness in all of us; both the consumers and the producers. Responding to this call should be our responsibility. We all have to carry it with us all the time, pass it on, let it be delivered by word of mouth, give it a viral quality to reach millions if not billions.

The American Management Association (AMA) has revealed in its survey that companies engaged in sustainable strategies are often the best financial performers. The survey shows that top management of companies that have implemented the strategies have been seen to champion the practice by extending their effort far down to the main objectives of a sustainable culture. [10, 27]

The critical measures of usability which are effectiveness, efficiency and satisfaction have a huge role in the production of goods and services. But designers and developers that are living in a sustainable culture have to be more concerned about the efficiency of the system in conjunction with the input resources. In my opinion, if the designer's satisfaction on the minimum efficiency of a system's resource requirement corresponds to the satisfaction of the consumers, then a sustainable environment has been kept. All of us, designers, developers, engineers and entrepreneurs have to be on the lookout for such imbalances in our environment and

try our best to close the gaps effectively for the sake of the good health of our mother earth. This research can change our previous culture of ink and paper consumption through the utilization of the different methods and techniques discussed. And I hope the methods and techniques presented can be supportive for the field of sustainable printing and a small contribution to the green movement.

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